TITLE OF THE INVENTION

PLASMA ETCHING APPARATUS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of Korean Patent Application No. 2003-52285, filed July 29, 2003, in the Korean Intellectual Property Office, the disclosure of which is incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0002] The present invention relates to a plasma etching apparatus, and, more particularly, to a plasma etching apparatus which improves etching uniformity by varying a shape of an upper electrode.

2. Description of the Related Art

[0003] High integration of a semiconductor has become increasingly important in the manufacturing process of the semiconductor. A more highly integrated semiconductor requires a more precise manufacturing process of a wafer. Accordingly, a more precise etching has become an important matter in an etching process, which is the major process in the manufacturing process of the wafer.

[0004] General requirements for the etching process are high selectivity, a high etching rate, etching uniformity, stability in the manufacturing process, and protection of the wafer against damage. Herein, the precise etching refers to an etching having a precise control of the degree of the etching according to various etching variables, and that the degree of the etching according to the position on the wafer is uniform.

[0005] Two methods of the etching are a dry etching and a wet etching. The method of the etching is selected according to a property of the manufacturing process and the advantages and disadvantages that each method has. The wet etching is widely used because of the

advantages of lower costs, a high selectivity rate, a high etching rate, and reliability. However, the wet etching is not suitable to the precise etching required with an extremely small line width because it has a problem of an undercut, which is seen in a chemical etching having an isotropic property.

[0006] The wet etching is divided into a physical etching such as an ion milling, a physical-chemistry etching such as an RIE (reactive ion etching), and a chemical etching such as a plasma etching. Although the physical etching may be effective for a precise pattern transcription, due to an anisotropic property, the physical etching has a low selective rate. Contrarily, the plasma etching may have a good selectivity rate, however, it still has the problems that the isotropic etching has, such as the undercut.

[0007] Moreover, the etching process using plasma has a problem with etching uniformity due to the high-integration of the semiconductor, increased diameter of the wafer, and various parameters in the etching apparatus.

[0008] Herein below, among various devices to improve the etching uniformity, an embodiment according to Korean Patent Registration No. 252210 will be described with reference to FIG. 1 and FIG. 2, which illustrate an art varying the shape of an upper electrode in the plasma etching apparatus.

[0009] FIG. 1 and FIG. 2 illustrate a schematic configuration of the plasma etching apparatus according to a conventional art. As illustrated in FIG. 1, the conventional plasma etching apparatus comprises an upper electrode 15, a lower electrode 13, corresponding to the upper electrode 15, to place a substrate 14, such as a wafer, on, and a high frequency power generator 11 supplying high frequency power to the lower electrode 13.

[0010] Although not illustrated in the drawing, there is a vacuum chamber where the upper electrode 15, the lower electrode 13, and the substrate 14 are installed, along with a vacuum pump and a cooling system. These parts will be described in the detailed description of the preferred embodiment, as these parts are easily appreciated by those skilled in the art.

[0011] Herein, the lower electrode 13, or susceptor, supports the substrate 14, and functions as an electrode generating the plasma as the RF high frequency power generator 11, connected to the lower electrode 13, supplies the high frequency power.

[0012] The upper electrode 15, corresponding to the lower electrode 13, functions as the other electrode generating the plasma, and generally comprises a metal plate and a coil.

[0013] In the drawings illustrated, the lower electrode 13 is supplied with the high frequency power, while the upper electrode 15 is grounded. Contrarily, the lower electrode 13 may be grounded, while the upper electrode 15 is supplied with the high frequency power.

[0014] Meanwhile, the substrate 14 placed on the lower electrode 13 generally has a deformation of an upward protrusion in the middle area, to a certain degree, due to a discharging pressure of cooling gas discharged from the cooling system (not shown) installed below the lower electrode 13 to improve the etching uniformity. Also, the strength of an RF electromagnetic field formed by the plasma is in inverse proportion to the distance between the upper electrode 15 and the substrate 14, and the etching uniformity is determined by the strength of the RF electromagnetic field and the density of the plasma on a specific point.

[0015] Herein, it is required to keep the distance between the upper electrode 15 and the substrate 14 constant to have better etching uniformity by the plasma.

[0016] Accordingly, the upper electrode 15 corresponding to the lower electrode 13 should have a constant curvature to a certain degree, so that the middle area of the upper electrode 15 is depressed.

[0017] To the contrary, the middle area of the upper electrode may be formed to protrude downward to a certain degree if the etching in the middle area is not effective due to other parameters (refer to FIG. 2).

[0018] However, in the plasma etching apparatus having the upper electrode of various shapes such as described above, it is not easy to shape the upper electrode with the constant curvature with consideration of the deformation of the substrate.

SUMMARY OF THE INVENTION

[0019] Accordingly, it is an aspect of the present invention to provide a plasma etching apparatus which improves etching uniformity by providing an upper electrode with a discontinuously shaped surface, which is convenient for shaping.

[0020] Additional aspects and/or advantages of the invention will be set forth in part in the description which follows and, in part, will be obvious from the description, or may be learned by practice of the invention.

[0021] The foregoing and/or other aspects of the present invention are achieved by providing a plasma etching apparatus having an upper electrode, a lower electrode corresponding to the upper electrode, to place a substrate on, and a high frequency power generator generating plasma by applying high frequency power to the upper electrode or the lower electrode, wherein a distance between the upper electrode and the lower electrode varies discontinuously on a portion of opposite surfaces of the electrodes by varying the shape of the upper electrode.

[0022] According to an aspect of the invention, the distance between the upper electrode and the lower electrode may vary discontinuously on a majority of the opposite surfaces of the electrodes.

[0023] According to an aspect of the invention, the distance between the upper electrode and the lower electrode may vary discontinuously on an entirety of the opposite surfaces of the electrodes.

[0024] According to an aspect of the invention, the upper electrode may be formed with at least one depression having sloped, stair-shaped sides.

[0025] According to an aspect of the invention, the upper electrode may be formed with a plurality of protrusions and depressions, and the protrusions and depressions may be symmetric about a point in the center of the upper electrode.

BRIEF DESCRIPTION OF THE DRAWINGS

[0026] These and/or other aspects and advantages of the invention will become apparent and more readily appreciated from the following description of the embodiments, taken in conjunction with the accompany drawings of which:

FIGS. 1 and 2 are schematic configurations of a plasma etching apparatus according to embodiments of a conventional art;

FIGS. 3 and 4 are schematic configurations of a plasma etching apparatus according to embodiments of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0027] Reference will now be made in detail to the embodiments of the present invention, examples of which are illustrated in the accompanying drawings, wherein like reference numerals refer to the like elements throughout. The embodiments are described below to explain the present invention by referring to the figures.

[0028] FIGS. 3 and 4 are schematic configurations of a plasma etching apparatus according to an embodiment of the present invention. As illustrated in FIG. 3, a plasma etching apparatus 20 according to an embodiment of the present invention comprises an upper electrode 25, a lower electrode 23 corresponding to the upper electrode 25 to place a wafer or a substrate 24 on, and a high frequency power generator 21 supplying high frequency power to the lower electrode 23.

[0029] The plasma etching apparatus 20 generally further comprises a gas supplier (not shown) supplying gas reacting to plasma, a vacuum pump 22 discharging the supplied gas and turning a vacuum chamber (not shown) into a vacuum state, and a cooling pipe (not shown) provided in the lower electrode 23 and controlling a temperature of the lower electrode 23 to achieve an improved result (or a uniform etching or a required degree of the etching).

[0030] The upper electrode 25, the lower electrode 23, and the substrate 24 are installed inside the vacuum chamber of the plasma etching apparatus 20, etching the wafer using the plasma generated by the lower electrode 23 supplied with the high frequency power from the high frequency power generator 21 and the grounded upper electrode 25.

[0031] Herein, the lower electrode 23, or susceptor, supports the substrate 24 and functions as an electrode connected to the RF high frequency power generator 21 supplying the high frequency power and generating the plasma.

[0032] The upper electrode 25, corresponding to the lower electrode 23, functions as the other electrode generating the plasma, and generally comprises a metal plate and a coil.

[0033] In the drawings illustrated, the lower electrode 23 is supplied with the high frequency power, while the upper electrode 25 is grounded. Conversely, the lower electrode 23 may be

grounded, while the upper electrode 25 is supplied with the high frequency power, or the upper electrode 25 and the lower electrode 23 may be supplied with the high frequency power.

[0034] The upper electrode 25, corresponding to the lower electrode 23, is distinctively shaped to make a distance between the upper electrode 25 and the lower electrode 23 discontinuous for the surfaces of the electrodes.

[0035] Herein, the surface of the upper electrode 25 may be formed to make the distance between the upper electrode 25 and the lower electrode 23 vary discontinuously for a small part of the surfaces of the electrodes, or for most of the surfaces of the electrodes.

[0036] As illustrated in FIG. 3, the upper electrode 25 is formed to make the distance between the upper electrode 25 and the lower electrode 23 discontinuous for a small part of the surfaces of the electrodes. Herein, the upper electrode 25 is formed with four protrusions, including projected edge portions and three depressions in the sectional view. The shape of the upper electrode 25 in the drawing is an exemplary illustration, however, the number and the size of the protrusions and depressions on the surface of the upper electrode 25 may vary as necessary.

[0037] Another embodiment of the plasma etching apparatus according to the present invention is illustrated in FIG. 4. The upper electrode 26 has depressions on most of the surface, making the distance between the upper electrode 26 and the lower electrode 23 differ according to a position on the surface. Specifically, the upper electrode 26 is formed with four protrusions, including projected edge portions and three depressions in a sectional view, wherein the depression in the middle of the surface has sloped sides shaped like stairs.

[0038] The shape of the upper electrode 26 in the drawing is an exemplary illustration. However, the number and the size of the protrusions and depressions on the surface of the upper electrode 26 may vary as necessary. Also, the upper electrode may be formed only to have slope sides shaped like stairs.

[0039] Herein, the protrusions and the depressions are formed on proper positions of the surface with consideration of the density of the plasma generated in the plasma etching apparatus 20 to have the uniform etching.

[0040] The strength of the RF electromagnetic field can be controlled by adjusting the distance between the upper electrode 25 and the substrate 24 by forming the protrusions and the depressions, because the strength of the RF electromagnetic field formed by the plasma is in inverse proportion to the distance between the upper electrode 25 and the substrate 24. The etching uniformity is determined by the strength of the RF electromagnetic field and the density of the plasma of a specific point.

[0041] In other words, the etching rate is adjusted to be uniform for all parts of the etched substrate 24 by compensating the density of the plasma, affected by various parameters, with the strength of the RF electromagnetic field applied to the upper electrode 25 or 26 by varying partially the distance between the upper and lower electrodes.

[0042] Herein, it is preferable that the depth or the height of the protrusions and the depressions should be slight enough not to affect distribution of the gas used in the etching process according to the shape of the electrode.

[0043] Furthermore, the upper electrode 25 or 26, having the protrusions and the depressions, and corresponding to the lower electrode 23, is preferably parallel to the lower electrode 23, because shaping the upper electrode in this manner is more convenient than shaping the upper electrode with the constant curvature.

[0044] Additionally, the protrusions and the depressions are preferably symmetric about a point in the center of the upper electrode 25 or 26, because the substrate 24 processed with the plasma is generally shaped like a disk plate.

[0045] With a configuration described above, the strength of the RF electromagnetic field can be controlled to improve the etching uniformity by making the distance between the upper electrode and the lower electrode discontinuous for the surfaces of the upper and lower electrodes. Also, the upper electrode can be shaped more conveniently by providing the upper electrode parallel to the lower electrode.

[0046] Although a few embodiments of the present invention have been shown and described, it will be appreciated by those skilled in the art that changes may be made in these embodiments without departing from the principles and spirit of the invention, the scope of which is defined in the appended claims and their equivalents.